

REMARKS

Claims 1-23 are pending in the present Application. Claim 1 has been amended, Claims 10, 20, and 22 have been canceled, and no claim has been added, leaving claims 1-9, 11-19, 21, 23, and 24 for consideration upon entry of the present Amendment.

Amendments to Claims

Claim 1 has been amended to include the limitations of claims 10, 20, and 22, canceled herewith.

No new matter has been introduced by these amendments.

Claim Rejections Under 35 U.S.C. § 103(a)

Claims 1-3, 5-8, 10, 12-13, and 23-24 stand rejected under 35 U.S.C. §103(a) as being unpatentable over JP publication 06-056921 (“Oshida”), in combination with JP publication 2001-329021 (“Kurokawa”).

In addition, Claims 1, 4, 9, 11, and 14-23 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Kurokawa in combination with Oshida.

Applicants respectfully traverse both of these rejections, and as the cited art is identical in both sets of rejections, Applicants respond to both rejections simultaneously hereinbelow.

Oshida discloses a method of imidizing a styrene-maleic anhydride copolymer to provide improved impact resistance by kneading the copolymer at a shear rate of greater than 10 sec^{-1} in the presence of an imidization agent, at a temperature of 200-270°C. ¶¶ [0004]-[0005]. The precursor copolymer comprises 60-90 wt% of aromatic vinyl monomer and 10-40 wt% of unsaturated dicarboxylic anhydride. ¶ [0009]. The imidization agent can be a primary or secondary amine, or ammonia, and may be introduced into the imidization reaction as a gas, aqueous solution, or other solution. ¶ [0010-[0012]. Decomposition of the copolymer is avoided by the low shear rate of the kneading. ¶ [0015]. Low molecular weight contaminants can be removed during the kneading (i.e., melt-volatilization extrusion) by applying vacuum to 50-200 torr. ¶ [0017]. Preparation of an exemplary styrene-maleic anhydride copolymer was carried out by polymerizing styrene, methyl methacrylate, an

initiator, and maleic anhydride in MIBK in a continuous polymerization reactor to a conversion of 65% at a temperature of 150°C, at a rate of 2.0 Kg/hr, followed by devolatilization at 200°C/50 torr to separate unreacted monomer and solvent from the polymer. ¶¶ [0021]-[0022].

Kurokawa discloses a multistep method for production of imidized polymer in which 1.) a terpolymer having 45-80 wt% vinyl aromatic monomers, 20-50 wt% of dicarboxylic acid anhydride monomer and 0-30 wt% of other vinyl monomers is polymerized in a multistage continuous polymerization apparatus at 60-200°C in a ketone solvent, to a conversion of 95% or greater of monomer; 2.) an amine is added continuously to convert 70 mol% or more of the (polymerized) dicarboxylic acid anhydride monomer to imide; and 3.) continuous devolatilization of the imidized polymer under reduced pressure and at a temperature of 180-330°C. ¶ [0005]. Homogeneity in the terpolymer prior to imidization is maintained by feeding the dicarboxylic acid anhydride according to its “quantitative ratio”. ¶ [0006]. Inclusion of less than 45 wt% of the vinylaromatic monomer in the terpolymer results in defects in mechanical characteristics, dimensional stability, and color tone. ¶ [0009].

For an obviousness rejection to be proper, the Examiner must meet the burden of establishing that all elements of the invention are disclosed in the prior art; that the prior art relied upon, or knowledge generally available in the art at the time of the invention, must provide some suggestion or incentive that would have motivated the skilled artisan to modify a reference or combined references; and that the proposed modification of the prior art must have had a reasonable expectation of success, determined from the vantage point of the skilled artisan at the time the invention was made. *In re Fine*, 5 U.S.P.Q.2d 1596, 1598 (Fed. Cir. 1988). The obviousness inquiry also requires consideration of common knowledge and common sense. *KSR Int'l Co. v. Teleflex Inc.*, 127 S.Ct. 1727, 1742-43 (2007); *DyStar Textilsfarben GmbH & Co. Deutschland KG v. C.H. Patrick Co.*, 464 F.3d 1356, 1367 (Fed. Cir. 2006) (“Our suggestion test is in actuality quite flexible and not only permits, but requires, consideration of common knowledge and common sense.”)

Claim 1 claims a method for producing an imide-substituted polymer that has desirably high heat resistance, where its heat resistance is maximized by preventing the formation of polystyrenes. As specifically claimed in Claim 22, the amount of polystyrene

that remains in the imide-substituted polymer prepared by the method of Claim 1 is less than 3% by weight polystyrene homopolymer. Neither Oshida nor Kurokawa teaches or discloses this limitation. As disclosed in the instant Specification, the presence of polystyrenes causes reduction of heat resistance, which can be seen by a comparison of the results of Example 1 to those of Comparative Examples 2 and 3 (p. 33-34, Tables 1 and 2). Also in the Specification, it is noted that the lower residual polystyrene content of the polymer prepared in Example 1 provides superior heat resistance when compared to the material of the Comparative Examples with a higher polystyrene content. See Specification p. 34, lines 2-6.

The Examiner states, regarding the limitation of Claim 20, herewith included in Claim 1 as amended, that the limitation thereof is answered by the passage in Kurokawa wherein it states that “conversion of an aromatic series vinyl monomer and a partial saturation anhydride monomer to 95% of the weight or more, respectively. See Final Office action dated January 9, 2008, p. 5, last 2 lines; also Kurokawa, ¶[0005]. Applicants do not agree with the Examiner’s assessment, and assert that this does not sufficiently teach or disclose the limitation in question. Kurokawa merely discloses that the *conversion of monomer* is 95%, which by definition means that 5% or less of *monomer* remains unconverted into polymer. Kurokawa is silent as to the presence of *polystyrene*, which is as will be readily appreciated by one skilled in the art, a polymer prepared by polymerization of styrene monomer (i.e., the aromatic series vinyl monomer of Kurokawa). Kurokawa thus only discloses that there may be 5% or less of unreacted *monomer* present, but this is a completely separate issue from that claimed in Claim 20 (now Claim 1). There is no teaching within this or any other portion of the disclosure of Kurokawa that would lead one skilled in the art to provide a method of polymerizing and devolatilizing that results in the production of a polymer having an aromatic vinyl *homopolymer* (e.g., polystyrene) content of less than 3%, or a copolymer with an aromatic vinyl *homopolymer* content of less than 3%. Thus, the combinations of Kurokawa and Oshida fail to teach or disclose all elements of the instant claims.

Furthermore, each reference is silent as to providing any motivation for maintaining a polystyrene homopolymer content of less than 3%. To reiterate arguments already on record, but which Applicants feel summarize the unexpected results associated with the limitation of less than 3% aromatic vinyl homopolymer content as claimed in claim 1, Applicants wish to

draw the Examiner's attention to the Specification, in which high heat resistance is illustrated by the high glass transition temperature of the products of the Examples of up to 191.5°C, which is superior to the products of the Comparative Examples ranging from 164.5°C to 177.8°C, where the compositions of the Examples, as reported in Table 1 (44.1-54.5 wt% of aromatic vinyl units, 0-1.3 wt% unsaturated dicarboxylic anhydride units, and 44.6-54.9 wt% imidized_units), were in accord with Claim 1. See Specification, p. 34. Oshida and Kurokawa are each silent as to the glass transition temperature of the polymers produced by their respective methods. Therefore, all combinations of Oshida and Kurokawa fail to disclose or teach all elements of the instant claims, and further fail to provide a suggestion or incentive that would motivate one skilled in the art to modify the combination to arrive at the polymer having less than 3% of aromatic vinyl homopolymer as claimed in Claim 1.

Further, since the reactivity of the aromatic vinyl monomers and unsaturated dicarboxylic anhydride monomers are different, the presence of the less reactive or excess monomers late in the copolymerization step is also a primary factor in preventing the formation of polystyrene homopolymer. By using a relatively short (2.0-5.0 hour) reaction time in the copolymerization step as disclosed, polystyrene formation, which occurs after the unsaturated dicarboxylic anhydride monomers having higher reactivity relative to the aromatic vinyl monomer are fully consumed, can thereby be prevented in advance. Accordingly, amendment of claim 1 to claim the residence time in the copolymerization step of 2.0 to 5.0 hours, can maximize the heat resistance by minimizing production of undesired polystyrene side product as well as minimizing reaction time. Claim 1 is therefore distinguished from Oshida which teaches an exemplary throughput in the continuous feed polymerization of 2.0 Kg/h, but fails to teach a total reaction residence time. Kurokawa is also silent as to the total residence time of the monomers being polymerized. Thus, neither Kurokawa nor Oshida, in any combination, disclose this element of the instant claims, nor does the combination provide a teaching or suggestion that would motivate one skilled in the art to modify the combination of Oshida and Kurokawa to limit the total polymerization residence time to 2.0 to 5.0 hours. Thus, the combinations of Oshida and Kurokawa neither teach all elements of the instant claims or provide a suggestion or incentive that would motivate one skilled in the art to combine the references to provide the invention as claimed

in instant Claim 1, and cannot therefore make the instant claim 1 unpatentable.

The composition ratio of the imide-substituted polymer prepared by the present invention is optimized for heat resistance, as illustrated by the discussion of the Examples, in particular Examples 2 to 4. See Specification, p. 35, line 21. Accordingly, claim 1, amended herewith to claim a polymer having a composition comprising 40-55% wt% of aromatic vinyl units, 0-5.0 wt% of unsaturated dicarboxylic anhydride units, and 40-60 wt% of the imidized units from unsaturated dicarboxylic anhydride units, and as produced by the method of claim 1, has excellent heat resistance.

Reducing the formation of aromatic vinyl homopolymers such as polystyrenes as claimed in the instant claims is essential to obtaining the desired improvement in heat resistance. The examples of instant Specification on pp. 33-34, tables 1 and 2, in which “the content of aromatic vinyl homopolymers contained in the imide substituted polymer manufactured through the devolatilization step is less than 3 wt%”, as claimed in original claim 22 and now present in Claim 1 as amended. Maintaining the concentration of aromatic vinyl homopolymers (e.g., polystyrene) at such low concentrations is necessary to maximize the improvement in heat resistance.

Control of the formation of polystyrene is accomplished in the claimed method by controlling the molar ratio of aromatic vinyl monomers to unsaturated dicarboxylic anhydride monomers at 0.67:1 to 6.0:1 as in amended claim 1. Neither Oshida nor Kurokawa discloses this ratio of monomers necessary to prevent the formation of polystyrenes.

Aromatic vinyl monomers are disclosed in the instant Specification on p. 8, lines 2-6 where exemplary such monomers are styrene (i.e., aromatic vinyl) derivatives. Applicants do not disclose methyl methacrylate. The Examiner states, in the Final Office action dated January 9, 2008 on p. 2, that because of the similarity of the molecular weights of maleic anhydride, styrene, and methyl methacrylate (the latter of which Applicants note corresponds to neither of the aromatic vinyl monomer nor the unsaturated dicarboxylic anhydride), that the limitation of a corresponding molar feeding ratio of less than 6:1 (as stated by the Examiner, or as actually claimed in instant Claim 1: “mole ratio of the aromatic vinyl monomers to the unsaturated dicarboxylic anhydride monomers is 0.67-6.0:1”) is met. Applicants respectfully disagree that Oshida, as relied upon by the Examiner, discloses this. Oshida discloses

continuously feeding a mixture of styrene (88.9 %) and methyl methacrylate (4 %), initiator (0.011 %) and methyl ethyl ketone (7.1 %) at a rate of 0.4 Kg/hr to an unspecified quantity of maleic anhydride. Oshida, ¶ [0021]. Unreacted monomer was removed by devolatilization and the reaction was run to a conversion of 65%, to recover a polymer having a composition of 69/26/5 styrene/maleic anhydride/MMA (presumably on a weight basis). Oshida, ¶ [0022]. One skilled in the art can and will discern no disclosure or teaching of a molar ratio of styrene (corresponding to an aromatic vinyl monomer) to maleic anhydride (an unsaturated dicarboxylic anhydride) in this, as the quantity of maleic anhydride in the feed was not specified; furthermore the final ratio of styrene to maleic anhydride in the resulting polymer can at best only be inferred, and inaccurately at that, from a final terpolymer composition (not a copolymer as claimed in instant Claim 1) run to a monomer conversion of 65% in the example cited by the Examiner. This in no way reflects the process claimed in Claim 1, which does not disclose a terpolymer, and which requires at least 95% conversion of the unsaturated vinyl aromatic monomer which is not disclosed in the cited Example.

Furthermore, as acknowledged by the Examiner, Oshida represents a continuous flow process in contrast to the batch process of the instant invention. One skilled in the art will readily appreciate that polymerization method affects the conversion and the instantaneous feed composition and hence would not be expected to provide the identical polymers and side products.

One skilled in the art will readily appreciate that the reactivities of the monomers (aromatic vinyl monomer and unsaturated dicarboxylic anhydride as claimed) are different and the residence time in the copolymerization step exerts control over the conversion and feed as mentioned above. Polymerization is prevented by quenching the polymerization reaction prior to introduction of the more reactive monomer, i.e., the unsaturated dicarboxylic anhydride monomer is completely exhausted. In addition, the temperature of the copolymerization also exerts control over the composition and feed. Hence, the claim limitation is disclosed in amended claim 1 to be “wherein the residence time in this step is within the range of 2.0 to 5.0 hours and the temperature of the polymerization in this step ranges from 80 to 150°C.

Oshida and/or Kurokawa do not disclose any interrelationship between these factors, and between these factors and the relationship of these factors to achieving heat resistance improvement. As the Examiner has further acknowledged, the residence time is not identical for continuous flow reactions and for batch reactions, and consequently, the conditions are not interchangeable. There can be no reasonable expectation therefore that the use of the conditions of residence time, temperature, and reaction method in any combination of Oshida and Kurokawa would provide the polymer having less than 3% of polystyrene as claimed in instant Claim 1.

The composition ratio of the imide substituted polymer (final product) and the polymerization and imide substitution steps have the optimized ratio that provides the desired heat resistance as described hereinabove. As claimed, proportions of “40-55 wt% of aromatic vinyl units, 0-5 wt% unsaturated dicarboxylic anhydride units, and 40-60 wt% imidized units from unsaturated dicarboxylic anhydride units” provides the base polymer having the desired heat resistance.

The Examiner cites the imide substituted polymer in Oshida which includes 60-90 wt% of aromatic vinyl monomer and 10-40 wt% of unsaturated dicarboxylic anhydride is not the composition ratio for the final products as claimed, i.e., the imide substituted polymer, but indicates the amounts of each monomer introduced in the polymerization step. Oshida does not disclose the actual composition ratio of the imide substituted polymer but indicates the amounts of the monomer charged during the polymerization step. Accordingly, since the composition ratio described in the amended Claim 1 discloses technical features limited specifically for improvement in heat resistance, a feature not disclosed in Oshida or Kurokawa, the present invention is thus nonobvious.

The present invention provides the imide substituted polymer in high yield corresponding with the improvement in heat resistance, That is, the conversion rate of unsaturated dicarboxylic anhydride monomer during polymerization is a factor considered to control the process and hence is an important technical feature. Also as recited in Claim 1, “the conversion of the *unsaturated dicarboxylic anhydride* in this step is greater than 95 wt%. Though the Examiner has rejected this limitation in view of ¶ [0005] of Oshida, the limitation is not disclosed by this section of Oshida. Oshida discloses rather that the conversion rate of

the *polymerization step* is 65 wt% (See ¶ [0021]); however, the conversion rate required herein is significantly higher in the present disclosure (95 wt% or higher as claimed), and though Kurokawa discloses 95% or greater of monomer conversion, there is as discussed hereinabove no teaching or motivation provided that would lead one skilled in the art to apply this conversion to the disclosure of Oshida to minimize the aromatic vinyl homopolymer content of the instant claims and provide after imidization the high heat polyimide as claimed.

Thus, for at least the foregoing reasons, neither Oshida nor Kurokawa or any combination of these discloses, teaches, or suggests all elements of the instant claims, provides a teaching or suggestion that would have motivated one skilled in the art to modify the combination to provide the missing elements, nor is there any reasonable expectation that such combination of references would successfully provide the invention as claimed in the instant claims.

It is believed that the foregoing amendments and remarks fully comply with the Office Action and that the claims herein should now be allowable to Applicants. Accordingly, reconsideration and allowance are requested.

If there are any additional charges with respect to this Amendment or otherwise, please charge them to Deposit Account No. 06-1130.

Respectfully submitted,

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